

September 15, 2009

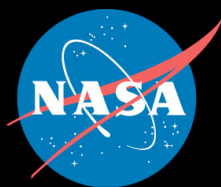
# *Space-Rush*

## *The Case for Infrastructure Based Exploration*

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## ***Space-Rush: The Case for Infrastructure Based Space Exploration***

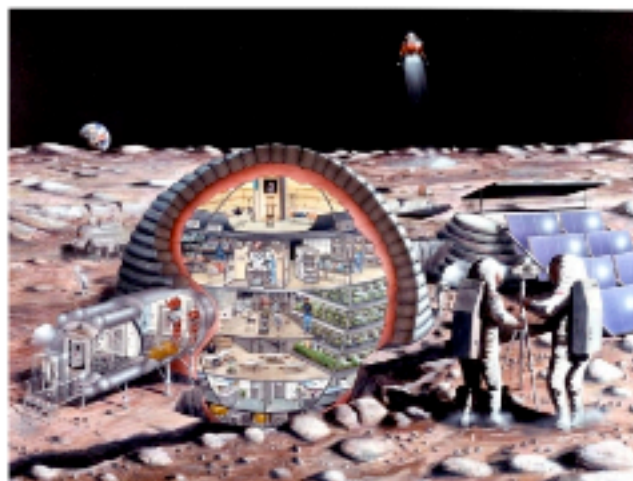
By:

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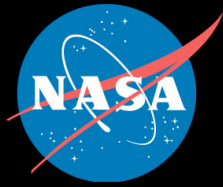


### **Background**

Since the time of Apollo most of NASA's space activities have used a "mission" based approach. This approach requires taking all, or almost all, of the resources needed from Earth at great expense and difficulty, with little if

benefits of the frontier back to the homeland, providing proof of the value of the new terrain. Taken together – establishment of infrastructure and engagement of private enterprise – the stage is set for very effective expansion and development.

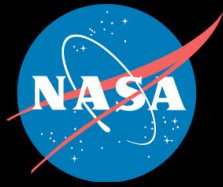
This is as true today as ever. Take for example the recent opening of an important frontier: the Internet. It was the government, specifically the Advanced Research Projects Agency (ARPA) that back in the late 1960's and 1970's put in place the first high-speed data lines between powerful computers in the US to support government and university researchers<sup>3</sup>. Had this high-speed data transfer capability remained the sole province of the government, few of us, outside of select government and university scientists, would ever have known of its existence or utility. Fortunately the door to this high-speed network was opened to



## *Background:*

- *NASA's space activities have used a "mission" based approach since Apollo*
- *Requires taking most of the resources needed from Earth*
- *Little establishment of infrastructure for future missions (ISS one clear exception)*
- *Relies principally on government funding and direction*
- *No significant engagement of private enterprise*





# *Opening New Frontiers:*

- *Opening the West provides a good example of what really opens the door to expansion:*

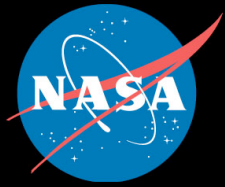
1. *A minimum level of infrastructure (e.g., railroads) is critical to promote growth*

- *Allows a great reduction in the resources required and the difficulties faced by pioneers that follow*

2. *Activity engaged private enterprise\* attracts entrepreneurs who find uses for the new terrain*

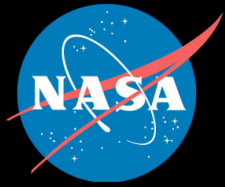
- *Entrepreneurs bring benefits of the frontier back to the homeland*
- *Provide proof of the value of the new terrain, and help maintain advocacy for the expansion*

*\* - (e.g. the Pacific Rail Way Act and the Homestead Act of 1862)*



# *As True Today as Ever:*

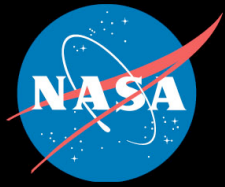
- *Take a recent new frontier: the Internet.*
- *Advanced Research Projects Agency (ARPA) in the late 1960's and 1970's put in place the first high-speed data lines between powerful computers*
  - *Government established the initial infrastructure*
  - *For government purposes*
- *Had this capability remained the sole province of the government, few of us would ever have known of its existence or utility*
- *Fortunately the door to high speed links opened to public use in the 1980's*
  - *Enter the entrepreneurs*
  - *And the Internet was born*
- *Few could have anticipated the economic and public benefit of e-Commerce and search engine technologies*
- *Largely led by Internet entrepreneurs*



# *A New Way Forward for Exploration*

- *Essential that lessons learned from the past be applied to our space program of today and tomorrow*
- *Both the government and private enterprise have critical tasks:*
  1. *The government must provide initial exploration and fund infrastructure*
  2. *Private industry must be actively engaged through serious planning*

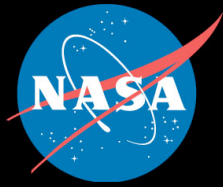




## *A New Way Forward for Exploration (Cont.)*

- *This approach will promote bringing back to Earth, and to the general public, the treasures of space:*
  - *New services (space tourism and entertainment)*
  - *Knowledge (fundamental new understanding of biology, physics and materials)*
  - *Products (new vaccines and protein crystals)*
  - *Resources (space based power, precious metals)*
  - *Increased security (protection from near-earth-objects)*
- *This will allow the general public to understand and appreciate the value of space and help maintain NASA's relevance*





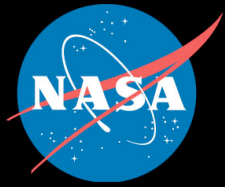
# *Space Infrastructure Categories*

- *Five key categories of infrastructure can be identified:*

- 1) Optimized Transportation*
- 2) Power and Communication*
- 3) Fuel and Water*
- 4) Crew Accommodations*
- 5) In-Situ Resource Utilization*







# *Optimized Transportation*

- *Three principle transportation segments:*

1. *Earth to Orbit (ETO) and return*

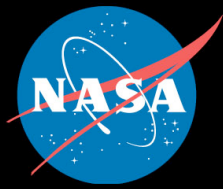
2. *Orbit to Orbit (OTO)*

- *Such as low-earth-orbit to geosynchronous, or low-earth-orbit to lunar orbit*

3. *Orbit to Extraterrestrial Surface (OTES)*

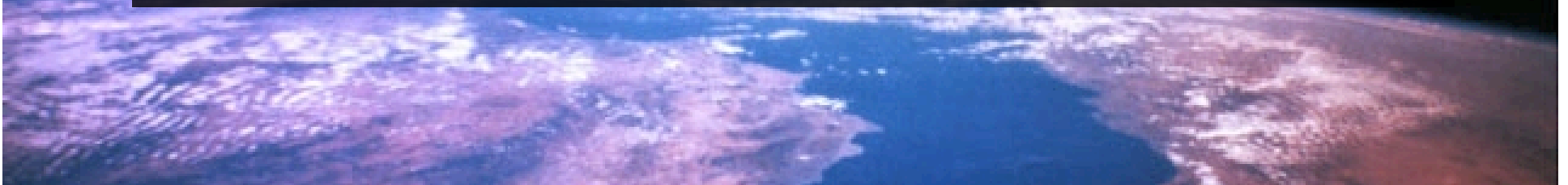
- *Such as lunar orbit to the lunar surface and return*

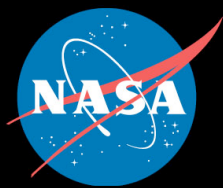




# Optimized Transportation (Cont.)

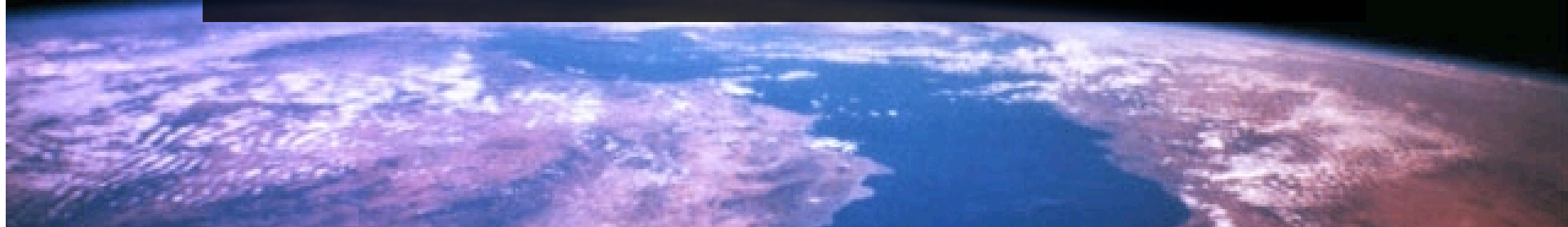
- *Since Apollo, NASA been focused almost exclusively on ETO:*
  - *Development of Shuttle in the 1970's & 80's*
  - *Shuttle-C and the National Launch Systems in the 1980's*
  - *National Aerospace Plane in the late 80's and early 1990's*
  - *X-planes (X-33, X-34, X-38) era in the 1990's*
  - *Space Launch Initiative and Orbital Space Plane in the early 2000's*
  - *Constellation (Ares and Orion) presently*
- *Of all these efforts, only the Shuttle program has produced an operational vehicle, even though decades have passed and billions have been spent on these programs since Shuttle*
- *Need to invest in other transportation areas, as well as work more actively with commercial space*
- *The current NASA COTS & CRS should be extended and applied to other transportation segments to improve results*

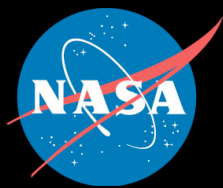




# *Power and Communications*

- *Second most important infrastructure after transportation*
- *Considerable present opportunity for development of space based power beaming and communication*
  - *Government capabilities in lasers and large satellites could provide initial demonstrations and infrastructure to points of interest, such as the lunar surface*
    - *Infrared laser power can be collected using the same photovoltaic arrays needed for solar power collection*
  - *Private enterprise could be engaged by government guaranteed minimum purchase agreements for in-space power and communications*
- *Installed in-space power and communication would revolutionize space vehicle design and capabilities*

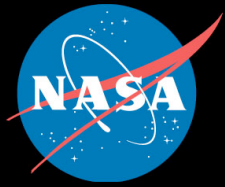




# *Fuel and Water*

- *Orbital fuel depots received considerable recent attention*
- *Storage of liquid oxygen and hydrogen on-orbit to enable refueling would dramatically improve transportation optimization*
  - > 10X increase in landed lunar mass, for example*
- *Also serves as a potent commercial stimulator for prospective fuel providers*
  - Market for frequent, low-cost launch could stimulate new reusable launch vehicles*
- *Availability of liquid oxygen and hydrogen yields water via fuel cells*
- *Government sponsored demonstration, followed by minimum government purchase agreements to engage private industry, is all that is needed to make it go*





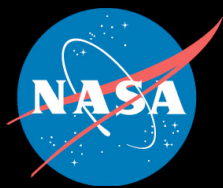
# *Space-Rush:*

*Based on Two Principles:*

- 1. Government established initial infrastructure*
- 2. Active engagement of private enterprise*

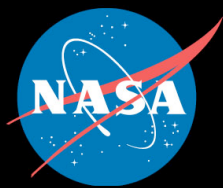
*Adoption will enable effective expansion and  
development of Space*





# Backup Slides

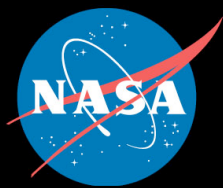




# Crew Accommodations

- *Transhab expandable modules a key new technology*
  - *First developed by NASA for future Mars missions*
  - *Licensed and pursued by Bigelow Aerospace, and demonstrated in space with their Genesis I & II spacecraft*
  - *Expandable space structures also being studied and developed by ILC Dover*
- *A government purchase of demonstration crew habitats from commercial providers would greatly stimulate the market*
- *Additional government sponsored research needed on:*
  - *Closed-loop life support systems*
  - *Crew health assessments*
  - *Counter measures for extended zero-g and cosmic ray exposure*





# *In-Situ Resource Utilization*

- *Successful development and demonstration would support all other infrastructure areas*
- *Can yield important resources such as oxygen, hydrogen, metals and materials for solar photovoltaic cells*
- *More government sponsored research and in-space demonstrations critical for development and adoption*
  - *Basic extraction approaches need investigation and in-space validation*
  - *May require complex in-space activities, with advanced automation and robotics*
  - *Need to demonstrate adequate efficiency and reliability*
- *Development would revolutionize space exploration and expansion*

